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(54) **MELTING MATERIAL SUPPLY APPARATUS**

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F27D 1/18 (2006.01)

(52) **U.S. Cl.**
CPC ***F27B 14/12*** (2013.01); ***F27D 1/18*** (2013.01); ***F27D 1/1808*** (2013.01); ***F27D 3/06*** (2013.01)

(58) **Field of Classification Search**
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(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,080,158 A * 3/1963 Stenzel F27D 3/06 193/4
4,089,640 A 5/1978 Overmyer et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 203893672 U 10/2014
JP S52-145546 U1 11/1977
(Continued)

OTHER PUBLICATIONS

Korean Office Action dated Jun. 19, 2018 issued by the Korean Patent Office in corresponding Korean Patent Application No. 10-2018-7011590, with English-language translation (8 pages).
(Continued)

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(57) **ABSTRACT**

The purpose of the present invention is to provide a melting material supply apparatus which is capable of contributing to improvements in the working environment and the melting efficiency of a metal melting furnace, and which is also capable of making melting work more efficient. This melting material supply apparatus for supplying a melting material to a crucible is provided with: a melting material supply unit for supplying the melting material to the crucible; and a furnace lid for closing an opening provided in the upper part of the crucible. The furnace lid is supported in a horizontal state by a furnace lid-supporter, and is capable of being moved between a position in which the opening is closed,
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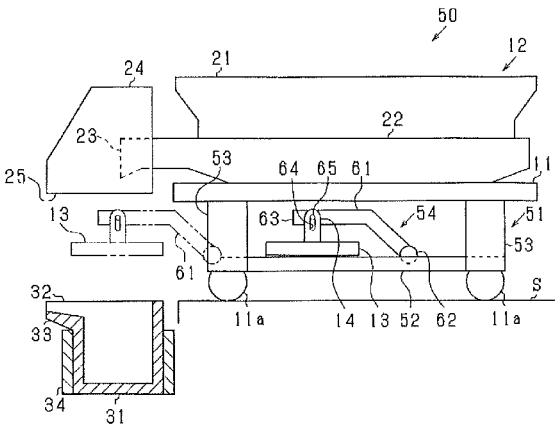

and a standby position located above a hood. When the furnace lid is in the standby position, the opening is open, and the melting material can be supplied into the crucible therefrom.

6 Claims, 4 Drawing Sheets

(58) **Field of Classification Search**
USPC 414/163, 164
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,151,919	A *	5/1979	Blase	C10B 43/06 15/93.2
6,036,914	A *	3/2000	Diederich	B22D 45/005 266/142
6,099,229	A *	8/2000	Knoch	C10B 25/24 202/241
8,596,945	B2 *	12/2013	Knoch	C10B 31/04 202/262
8,714,899	B2 *	5/2014	Schuecker	C10B 25/24 414/164

FOREIGN PATENT DOCUMENTS

JP	S58-092790	A	6/1983
JP	S61-016915	B2	5/1986
JP	H07-133987	A	5/1995
JP	11-029814	A	2/1999
JP	2003-164960	A	6/2003

OTHER PUBLICATIONS

International Search Report (PCT/ISA/210) dated Nov. 29, 2016, by the Japan Patent Office as the International Searching Authority for International Application No. PCT/JP2016/075836.
Written Opinion (PCT/ISA/237) dated Nov. 29, 2016, by the Japan Patent Office as the International Searching Authority for International Application No. PCT/JP2016/075836.
International Preliminary Report on Patentability (PCT/IPEA/409) dated Oct. 2, 2017, by the Japan Patent Office as the International Preliminary Examining Authority for International Application No. PCT/JP2016/075836 (with English translation of annexes).
Office Action dated Jul. 28, 2017, by the Japan Patent Office for corresponding Japanese Patent Application No. JP 2015-189557.
Office Action (The Third Office Action) dated May 13, 2019, by the State Intellectual Property Office (SIPO) of the People's Republic of China in corresponding Chinese Patent Application No. 201680054846.0 and an English Translation of the Office Action. (11 pages).

* cited by examiner

Fig. 1

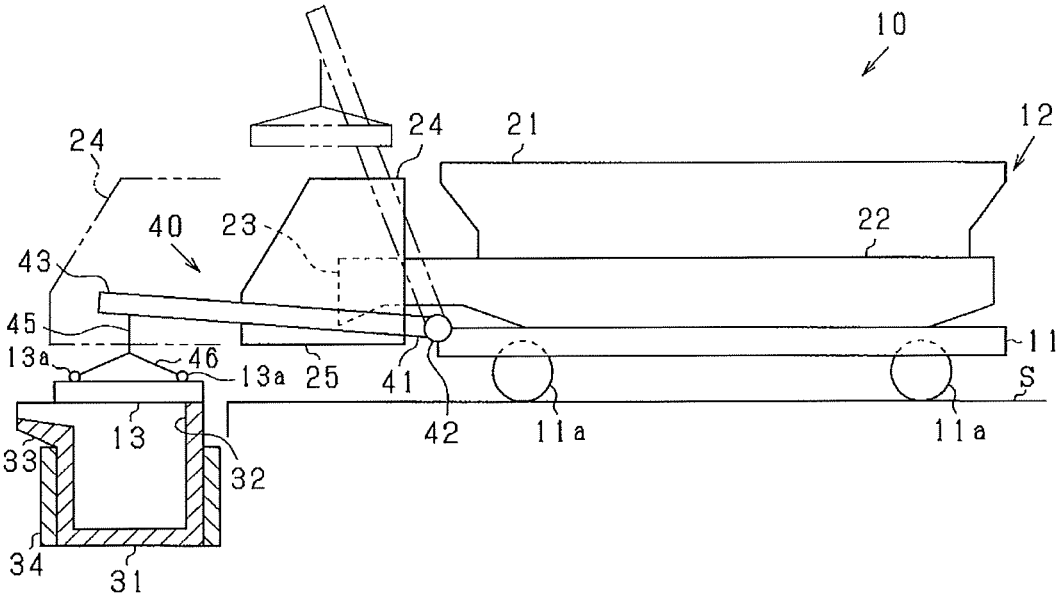
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Fig.2

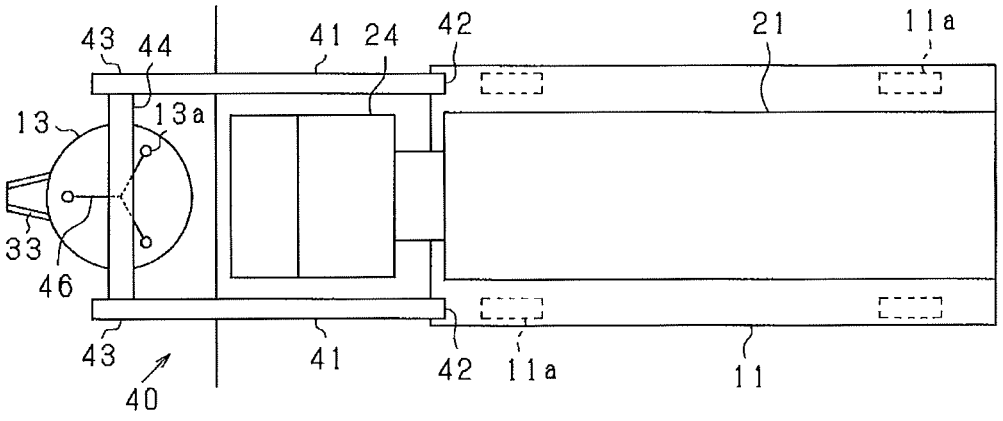

Fig.3

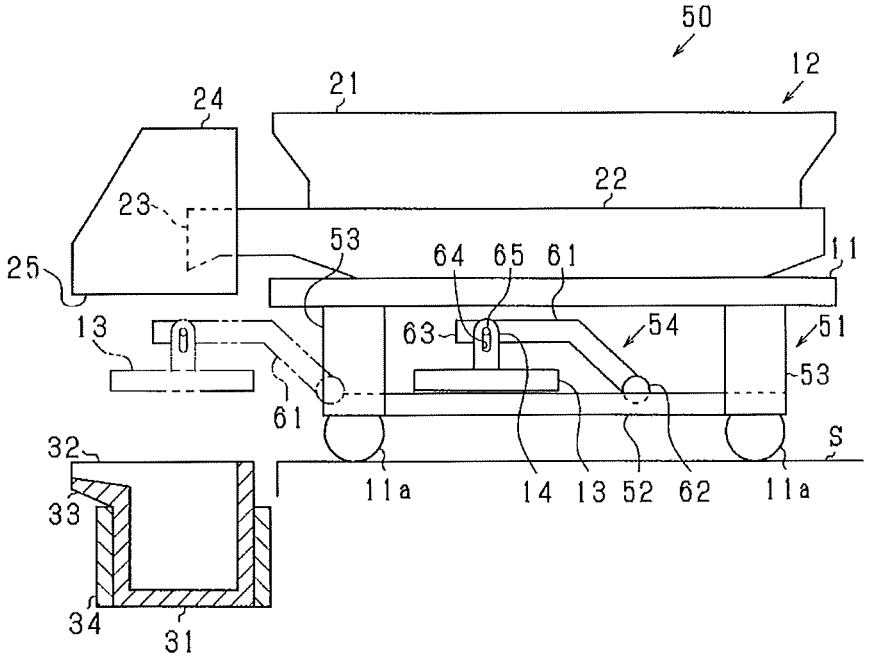
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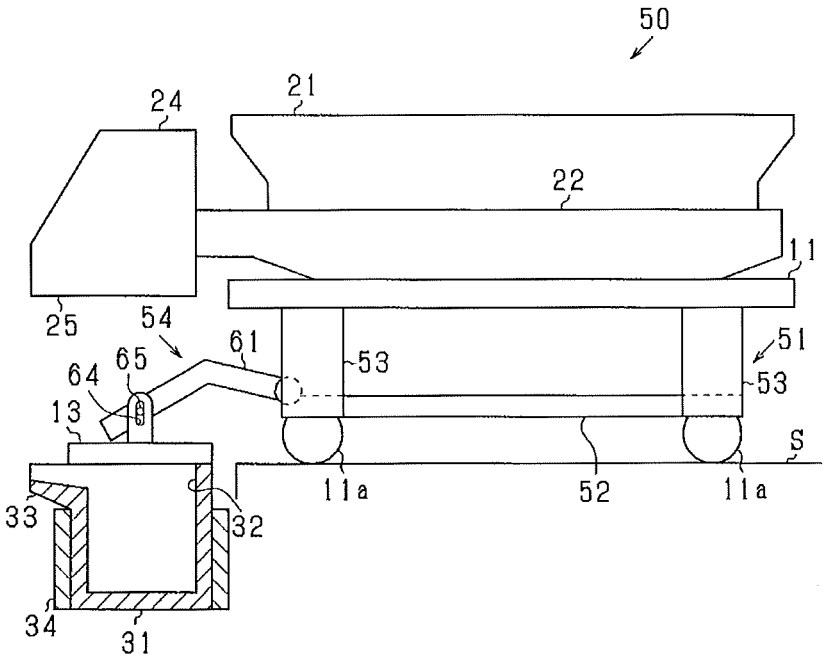
Fig. 4



MELTING MATERIAL SUPPLY APPARATUS

TECHNICAL FIELD

The present disclosure relates to a melting material supply apparatus configured to supply a melting material to a metal melting furnace.

BACKGROUND ART

In a casting process or the like for manufacturing casts by pouring molten metal into a casting mold, a metal melting furnace is used for melting a melting material (metal). In general, the metal melting furnace employs an induction furnace system configured to heat a melting material in a crucible by generating an induction current therein (for example, see Patent Literature 1).

The metal melting furnace of this type is provided in combination with a melting material supply apparatus configured to measure a required amount of the melting material for every casting process and supply the measured melting material into the crucible. With the melting material supply apparatus provided in combination, a casting cycle including supply of material, heating of material, transfer of a molten metal is established (see also Patent Literature 1).

CITATION LIST

Patent Literature

Patent Literature 1: Japanese Patent Laid-Open No. 2003-164960

SUMMARY OF DISCLOSURE

Technical Problem

In the metal melting furnace of the related art, an opening of the crucible is left opened toward outside. If the opening is left opened in this manner, heat in the crucible is dissipated through the opening during a process of melting the melting material, which may result in a problem of lowering of melting efficiency and deterioration of working environment around the metal melting furnace. Therefore, there has been room to study about possibilities to provide the melting material supply apparatus combined with the metal melting furnace with a function which addresses the heat dissipation issue.

Accordingly, it is an object of the present disclosure to provide a melting material supply apparatus which contributes to improving melting efficiency of the metal melting furnace and a working environment as well as achieving a melting operation with improved efficiency.

Solution to Problem

In order to achieve the above-described object, a first disclosure provides a melting material supply apparatus combined with a metal melting furnace for melting a melting material supplied to a crucible and configured to supply the melting material to the crucible, characterized in that the melting material supply apparatus includes: a melting material supply unit configured to supply a melting material to the crucible; a means configured to move the melting material supply unit between a position for supplying the melting material to the crucible and a position retracted therefrom and apart from the crucible which has been supplied with the melting material at the position for supplying; a furnace lid provided integrally with the melting material supply unit and configured to cover an opening provided at a top of the crucible; furnace lid-supporting means configured to support the furnace lid in a horizontal state; and furnace lid moving means configured to move the furnace lid supported by the furnace lid-supporting means between a first position at which the furnace lid is placed at the opening to cover the opening and a second position at which the opening is opened to allow a supply of the melting material.

The second disclosure according to the first disclosure is characterized in that the melting material supply unit has a hood disposed above the opening at the time of loading the melting material into the crucible and having a material outlet port configured to lead out the melting material downward, and in that the furnace lid at the first position is placed below the hood.

A third disclosure according to the second disclosure is characterized in that the furnace lid moving means-moves the furnace lid between the first position and the second position below the melting material supply unit.

A fourth disclosure according to the first disclosure is characterized in that the melting material supply unit has the hood disposed above the opening at the time of supplying loading the melting material into the crucible and having a material outlet port configured to lead out the melting material downward, in that the furnace lid at the first position is placed in front of the hood, and the furnace lid at the second position is placed above the hood, and in that the furnace lid moving means moves the furnace lid so as to circumvent the hood when moving the furnace lid between the first position and the second position.

A fifth disclosure according to any one of the first to fourth disclosures is characterized in that the furnace lid-supporting means has an inclination following mechanism configured to cause the furnace lid to incline so as to follow an inclination of a contact portion with respect to the opening.

Advantageous Effect of the Disclosure

According to the first disclosure, by moving the furnace lid to the second position by the furnace lid moving means, the opening of the crucible is opened and thus the supply of the melting material from the melting material supply unit into the crucible is allowed. After the melting material is supplied, the furnace lid is moved to the first position and the melting material is melted by induction heating or the like. At this time, as the furnace lid is placed at the opening of the crucible, heat in the crucible is hardly dissipated to the outside, and thus the melting efficiency and the working environment are improved.

In addition, in a state of retaining a molten metal, which is obtained by melting the melting material, in the crucible, the opening of the crucible may be kept covered by leaving the furnace lid placed at the first position. Therefore, the furnace lid may also be used as a furnace lid for retention of the molten metal. Accordingly, provision of another furnace lid as an additional apparatus and setting of the furnace lid by an operator for the retention of the molten metal are not necessary, and thus efficiency of the melting operation is also improved.

According to the second disclosure, the furnace lid moved to the first position and being in a state of covering the opening of the crucible is placed below the hood. By moving the furnace lid from below the hood to the second position,

the opening of the crucible is positioned below the hood, and thus the supply of the melting material from the material outlet port of the hood into the crucible is allowed. In other words, the melting material supply apparatus do not have to be moved for supplying the melting material and for melting the supplied melting material, and thus the efficiency of the melting operation is improved correspondingly.

According to the third disclosure, the furnace lid moving means is configured to move the furnace lid between the first position and the second position below the melting material supply unit, and an area for moving the furnace lid and an area used for the melting material supply unit may be provided separately in a vertical direction. Accordingly, complication in structure due to interference of one configuration with the other configuration is restricted.

According to the fourth disclosure, the furnace lid is moved between the first position to cover the opening of the crucible and the second position to open the opening so as to circumvent the hood. The furnace lid moved to the first position is placed in front of the hood. Therefore, by placing the hood at a position closer to the opening of the crucible, a distance between the material outlet port of the hood and the opening may be reduced. Accordingly, the melting material is restricted from splashing around when the melting material is supplied to the crucible, and thus a required amount of melting material may be supplied further reliably.

According to the fifth embodiment, as the furnace lid-supporting means includes an inclination following mechanism, even when the opening of the crucible is inclined, the furnace lid is placed at the opening of the crucible in a state of inclining so as to follow the inclination. Accordingly, even though the opening of the crucible is inclined, formation of an excessive gap between a peripheral edge of the opening and the furnace lid, which may lead to heat dissipation therefrom, may be restricted.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a side view schematically illustrating a melting material supply apparatus of a first embodiment.

FIG. **2** is a plan view of FIG. **1**.

FIG. **3** is a side view schematically illustrating a melting material supply apparatus of a second embodiment.

FIG. **4** is a schematic side view illustrating a state in which a furnace lid is placed at an opening.

DESCRIPTION OF EMBODIMENTS

Referring now to the drawings, embodiments in which the present disclosure is embodied will be described in detail.

First Embodiment

Referring first to FIG. **1** and FIG. **2**, a configuration of a melting material supply apparatus combined with a metal melting furnace according to a first embodiment will be described. FIG. **1** is a side view schematically illustrating the melting material supply apparatus of the first embodiment, and FIG. **2** is a plan view of FIG. **1**.

As illustrated in FIG. **1** and FIG. **2**, a melting material supply apparatus **10** of the first embodiment includes a base unit **11** and a melting material supply unit **12**. The base unit **11** includes a plurality of (four in the first embodiment) wheels **11***a*, and is capable of moving in one direction (a lateral direction in FIG. **1**, which will be referred to as "movement direction", hereinafter) on a traveling path S. A configuration to enable the melting material supply apparatus **10** to move may be a rail or the like.

A melting material supply unit **12** is installed on the base unit **11**, and includes a hopper **21** and a material feeder **22**. The hopper **21** is a container for storing a melting material such as cast iron or the like, and is opened on top. The melting material is loaded from the open portion, and the melting material is stored in the hopper **21**.

The material feeder **22** is provided at a lower end portion of the hopper **21**. The material feeder **22** is, for example, an oscillation conveyer or a belt conveyer, and has a function to feed a predetermined amount of the melting material stored in the hopper **21**. The material feeder **22** is provided with a material output portion **23** at a distal end thereof on one side in the movement direction (hereinafter, referred to as a "front side"). The hood **24** is provided around the material output portion **23**, and the material output portion **23** is covered with the hood **24**. A material outlet port **25** configured to lead the material to fall downward is provided at a lower portion of the hood **24**. The predetermined amount of the melting material led out from the material output portion **23** is guided to the material outlet port **25** by the hood **24** in a state of being restricted from splashing around, and is fallen downward therefrom.

A crucible **31** of the metal melting furnace is provided on the front side of the movement direction where the hood **24** is provided. The crucible **31** is a bottomed cylindrical container. An opening **32** is provided on top of the container, and through the opening **32**, the melting material is loaded into the crucible **31**. The crucible **31** is provided so that an upper end thereof comes substantially to the same level as that of the traveling path S. The crucible **31** is provided at the upper end thereof with a spout **33** projecting sideward from the opening **32**.

The metal melting furnace in this specification employs an induction heating system, and an induction coil **34** is provided on the crucible **31** so as to surround a periphery of the cylindrical portion. The melting material stored in the crucible **31** is subjected to induction heating by passing an AC current through the induction coil **34**, whereby the melting material is melted.

The melting material supply apparatus **10** of the first embodiment is provided with a furnace lid **13** to be placed at the opening **32** of the crucible **31**. The furnace lid **13** is supported by a furnace lid-supporting device **40**, and is provided on the melting material supply apparatus **10** in a state of being capable of changing in position. The furnace lid-supporting device **40** here corresponds to furnace lid-supporting means and furnace lid-moving means.

The furnace lid-supporter **40** includes a pair of arm members **41** as illustrated in FIG. **2**. The respective arm members **41** are provided so as to extend in the movement direction from a front end of the base unit **11** to the front side of the hood **24** along both sides of the hood **24**. Therefore, the pair of arm members **41** extend in parallel in plan view. Each of the arm members **41** is configured to be pivotable about a proximal end **42** thereof as an axis of pivotal movement.

The pivotal movement of the arm member **41** is achieved by driving a rotating drive unit (not illustrated). Examples of conceivable rotating drive unit (not illustrated) include a cylinder coupled at distal end of a rod to the arm member **41**. In this case, by driving the cylinder and retracting the rod, the arm members **41** may be pivoted from a lying position to a raised position.

A lateral member **44** is bridged between distal ends **43** of the respective arm members **41**. An end of a first suspension

line **45** is coupled to the lateral member **44** at a center portion in the longitudinal direction. On the other hand, at least three joint portions **13***a* are provided on a peripheral edge portion of the furnace lid **13** equidistantly from a center of gravity of the furnace lid **13**. Second suspension lines **46** are coupled to the respective joint portions **13***a* and converged toward a vertical line including the center of gravity of the furnace lid **13**. The other end of the first suspension line **45** is connected to a point where the second suspension lines **46** are converged. Therefore, the center of gravity of the furnace lid **13** exists on an extension of the first suspension line **45**. In this configuration, the furnace lid **13** is suspended and supported by the lateral member **44** in a horizontal state by means of the first suspension line **45** and the second suspension lines **46**.

The suspension lines **45**, **46** here include an elongated suspension tool such as a wire, a chain, and the like which is tensed in a state of suspending an object and is loosened when both ends get closer to each other to a distance shorter than an entire length thereof.

By making the respective arm members **41** lie down to move the furnace lid **13** downward, the furnace lid **13** is placed at the opening **32** of the crucible **31** and the opening **32** is covered as illustrated in a solid line in FIG. **1**. The position of the furnace lid **13** corresponds to the first position. In contrast, by pivoting and raising the respective arm members **41** from this position, the furnace lid **13** may leave the opening **32** and move to an upper level of the hood **24** as illustrated by a two-dot chain line in FIG. **1**. Accordingly, the opening **32** is opened and thus allows a supply of the melting material from above the opening **32**. A position of the furnace lid **13** above the hood **24** is defined as a waiting position, and the waiting position corresponds to the second position.

When the melting material supply apparatus **10** having the configuration described thus far is used to supply the melting material to the crucible **31**, a procedure as described below is performed.

First, when the melting material is supplied, the furnace lid **13** is placed at the waiting position, and in this state, the melting material supply apparatus **10** is moved forward to place the hood **24** above the opening **32** of the crucible **31** (see the two-dot chain line in FIG. **1**). In this state, a predetermined amount of the melting material stored in the hopper **21** is fed by the material feeder **22** of the melting material supply unit **12**. Accordingly, the melting material is led out from the material output portion **23**, and the predetermined amount of the melting material falls downward from the material outlet port **25** of the hood **24**. As the opening **32** of the crucible **31** exists in that downward area, the melting material is supplied to the crucible **31**.

Next, the melting material supply apparatus **10** is retracted, and then the respective arm members **41** are pivoted and laid down to a position where the furnace lid **13** covers the opening **32** of the crucible **31**. Accordingly, the opening **32** of the crucible **31** is covered with the furnace lid **13**. Therefore, by passing a current through the induction coil **34** to effect induction heating on the melting material in the crucible **31**, heating of the melting material is achieved while heat dissipation is restricted. For retention of the molten metal obtained by melting the melting material, the retention of the molten metal in the crucible **31** in a state of restricting the heat dissipation is achieved by maintaining the state in which the opening **32** is covered with the furnace lid **13**.

An extent of retraction of the melting material supply apparatus **10** is set depending on the length of the respective arm members **41**, the suspending position of the furnace lid **13**, and the like so that the furnace lid **13** is placed at the opening **32** when the arm members **41** are laid down.

The suspension lines **45**, **46** that suspend and support the furnace lid **13** are configured to be capable of being shortened by sagging (loosening). Therefore, when the upper end of the crucible **31** is not horizontal and is slightly inclined, the arm members **41** may further be laid down to absorb the inclination of the crucible **31** by the looseness of the suspension lines **45**, **46**. Accordingly, formation of the gap between the peripheral edge (contact portion) of the opening **32** of the crucible **31** and the furnace lid **13** is restricted. In this case, the suspension lines **45**, **46** correspond to the inclination following mechanism.

When the molten metal in the crucible **31** is used, the arm members **41** are pivoted to the raised position to restore the furnace lid **13** to the waiting position. Accordingly, the state in which the opening **32** of the crucible **31** is opened is achieved. Subsequently, when supplying the melting material into the crucible **31** again, the melting material supply apparatus **10** at the retracted position is moved forward, so that the hood **24** is placed above the opening **32** of the crucible **31** (see the two-dot chain line in FIG. **1**). In this state, the supply of the melting material is performed as described above.

Simultaneously with advancement and retraction of the melting material supply apparatus **10**, the movement of the furnace lid **13**, that is, the movement between the waiting position and the position to cover the opening **32** may be performed.

According to the melting material supply apparatus **10** of the first embodiment described thus far, the following effects are achieved.

When the arm members **41** are raised to place the furnace lid **13** at the waiting position, a state in which the opening **32** of the crucible **31** is opened is achieved, and thus the supply of the melting material from the melting material supply unit **12** into the crucible **31** is allowed. After the melting material is suppled, the arm members **41** are laid down to place the furnace lid **13** at the opening **32** to cover the opening **32** by the furnace lid **13**. By melting the melting material in this state, heat in the crucible **31** can hardly be dissipated to the outside. Accordingly, melting efficiency and working environment are improved.

For retaining the molten metal obtained after the melting material is melted in the crucible **31** as well, the state in which the opening **32** of the crucible **31** is covered continues by leaving the furnace lid **13** placed at the opening **32**, and thus the furnace lid **13** may be used also during the retention of the molten metal. Accordingly, provision of another furnace lid **13** as an additional device and setting of the furnace lid **13** by an operator for the retention of the molten metal are not necessary, and thus efficiency of the melting operation is also improved.

The furnace lid **13** is moved by the furnace lid-supporter **40** between a position to cover the opening **32** of the crucible **31** and a position to open the opening **32** so as to circumvent the hood **24**. The furnace lid **13** in the state of covering the opening **32** is placed in front of the hood **24**. Therefore, by placing the hood **24** at a position closer to the opening **32** of the crucible **31**, a distance between the material outlet port **25** of the hood **24** and the opening **32** of the crucible **31** may be reduced. Accordingly, the melting material is restricted from splashing around when the melting material is supplied to the crucible **31**, and thus a required amount of melting material may be supplied further reliably.

Since the furnace lid **13** is suspended and supported by the suspension lines **45**, **46**, when the upper end of the crucible **31** is inclined, the arm members **41** may further be laid down to absorb the inclination of the crucible **31** by the looseness of the suspension lines **45**, **46**. Accordingly, an event in which a gap is formed between the peripheral edge of the opening **32** of the crucible **31** and the furnace lid **13** and heat is dissipated therefrom is restricted.

Second Embodiment

Referring now to FIG. **3**, a configuration of a melting material supply apparatus according to a second embodiment will be described. FIG. **3** is a side view schematically illustrating a melting material supply apparatus of the second embodiment. Parts of configurations overlapping with the first embodiment described above are designated with the same names and reference numerals, and parts of the configuration different from that of the first embodiment will be mainly described.

As illustrated in FIG. **3**, in the melting material supply apparatus **50** of the second embodiment, the base portion **11** includes a furnace lid accommodating portion **51** for accommodating the furnace lid **13**. The furnace lid accommodating portion **51** is provided below the melting material supply unit **12**. Therefore, the melting material supply unit **12** and the hood **24** are located at a higher level by an amount corresponding to the furnace lid accommodating portion **51**.

The furnace lid accommodating portion **51** has a base table portion **52** having a flat plate shape, and the column members **53** are provided at four corners of the base table portion **52**. The melting material supply unit **12** is supported by these columns. The furnace lid **13** and the furnace lid supporting mechanism **54** configured to support the furnace lid **13** are provided in a space defined inside the column members **53**.

The furnace lid supporting mechanism **54** supports the furnace lid **13** in a horizontal state, and is a mechanism for making the position of the furnace lid **13** movable. Therefore, the furnace lid supporting mechanism **54** corresponds to the furnace lid-supporting means and the furnace lid-moving means. FIG. **3** illustrates a state in which the furnace lid **13** is suspended and supported by the furnace lid supporting mechanism **54** in the furnace lid accommodating unit **51**.

In the description given below, the state illustrated in FIG. **3** is defined as a reference position (waiting position). The furnace lid supporting mechanism **54** includes an arm member **61**. The arm member **61** is attached at a proximal end **62** thereof to the base table portion **52**. The proximal end **62** of the arm member **61** is attached to the melting material supply apparatus **50** at a center portion of in the width direction (a direction orthogonal to the paper plane of the drawing). The arm member **61** extends once from the proximal end **62** obliquely upward with respect to the movement direction, and then changes the direction into the horizontal direction.

The furnace lid **13** is provided at a center portion (a portion of center of gravity) with a coupling member **14** extending upward, and the coupling member **14** is coupled to a distal end **63** of the arm member **61**. An elongated hole **64** extending along a vertical direction is formed in the coupling member **14** at a coupled portion between the arm member **61** and the coupling member **14**. On the other hand, the arm member **61** is provided with a shaft portion **65** inserted into the elongated hole **64**. In this manner, the furnace lid **13** is suspended and supported by a distal end **63** of the arm member **61** in a horizontal state via the shaft portion **65** of the arm member **61** provided in the elongated hole **64** of the coupling member **14**.

As described above, the furnace lid supporting mechanism **54** has the configuration in which the arm member **61** is movable in the movement direction. This configuration may employ any suitable configuration such as that the arm member **61** is provided on a movable member which is movable on a rail on the base table portion **52**. In this configuration, the furnace lid **13** is allowed to move in the horizontal direction from the waiting position at which it is accommodated in the furnace lid accommodating portion **51** to a position at which it protrudes in front of the furnace lid accommodating portion **51** as illustrated by a two-dot chain line as illustrated in FIG. **3**. In this case, the furnace lid **13** is disposed below the hood **24**, and is disposed above the opening **32** of the crucible **31**. This is defined as an intermediate position.

In addition, in the furnace lid supporting mechanism **54**, the arm member **61** is configured to be pivotable about the proximal end **62** as a center of the pivotal movement. Therefore, when the arm member **61** is pivoted about the proximal end **62** from a state in which the arm member **61** and the furnace lid **13** are at the intermediate position indicated by the two-dot chain line in FIG. **3**, the furnace lid **13** moved downward as is and is placed at the opening **32** of the crucible **31**. FIG. **4** is a schematic side view illustrating a state in which the furnace lid **13** is moved downward and is placed at the opening **32**. As illustrated in FIG. **4**, with the furnace lid **13** placed at the opening **32** of the crucible **31**, the opening **32** is covered with the furnace lid **13**.

As described above, the elongated hole **64** is formed in the coupling member **14** at the coupled portion between the distal end **63** of the arm member **61** and the coupling member **14** provided on the furnace lid **13**, and the shaft portion **65** of the arm member **61** is provided in the elongated hole **64**. Therefore, the shaft portion **65** of the arm member **61** is movable along the elongated hole **64**, and the arm member **61** and the coupling member **14** are coupled with looseness at the coupled portion. In addition, with the shaft portion **65** formed into a circular shape in cross section, the coupling member **14** and the furnace lid **13** are also allowed to incline. Therefore, even when the crucible **31** is not in the horizontal state and is slightly inclined, the inclination is absorbed by this looseness. Accordingly, formation of the gap between the peripheral edge (contact portion) of the opening **32** and the furnace lid **13** is restricted. In this case, the elongated hole **64** and the shaft portion **65** constitute the inclination following mechanism.

In this manner, when the arm member **61** is raised from the position at which the furnace lid **13** is placed at the opening **32** of the crucible **31** by pivoting it about the proximal end **62**, the furnace lid **13** is restored again to the intermediate position. In addition, when the arm member **61** and the furnace lid **13** are moved to be accommodated in the furnace lid accommodating portion **51**, the furnace lid **13** is restored to the waiting position. In this manner, the furnace lid **13** is movable between the waiting position at which it is accommodated in the furnace lid accommodating portion **51** and the position at which it is placed at the opening **32** of the crucible **31** to cover the opening **32** via the intermediate position. The position to cover the opening **32** corresponds to the first position, and the reference position (waiting position) corresponds to the second position.

When the melting material supply apparatus **50** having the configuration described thus far is used to supply the melting material to the crucible **31**, a procedure as described below is performed.

First, when the melting material is supplied, the furnace lid **13** is placed at the waiting position, and in this state, the melting material supply apparatus **10** is moved forward to place the hood **24** above the opening **32** of the crucible **31** as illustrated in FIG. **3**. The melting material is supplied to the crucible **31** in this state.

Next, in a state of keeping the position of the melting material supply apparatus **50** as is, the furnace lid **13** is moved to and placed at the opening **32** of the crucible **31** via the intermediate position by the furnace lid supporting mechanism **54**. Accordingly, the opening **32** of the crucible **31** is covered with the furnace lid **13**. Therefore, heating of the melting material and the retention of the molten metal in the crucible **31** is achieved while heat dissipation is restricted.

In this case as well, even though the opening **32** of the crucible **31** is inclined, the inclination is absorbed by the looseness provided at the coupled portion between the distal end **63** of the arm member **61** and the coupling member **14**.

When the molten metal in the crucible **31** is used, the furnace lid **13** is restored to the original waiting position by the furnace lid supporting mechanism **54**. Accordingly, the state in which the opening **32** of the crucible **31** is opened is achieved. In this case, the material outlet port **25** of the hood **24** is positioned above the opening **32**. Therefore, the supply of the melting material into the crucible **31** is performed at the position as is without moving the melting material supply apparatus **50**.

According to the melting material supply apparatus **50** of the second embodiment described thus far, the following effects are achieved.

In the state in which the furnace lid **13** is placed in the furnace lid accommodating portion **51**, that is, in the state where the furnace lid **13** is placed at the waiting position, the opening **32** of the crucible **31** is opened. Therefore, the supply of the melting material from the melting material supply unit **12** to the crucible **31** is allowed. After the melting material is supplied, the furnace lid **13** is moved and placed at the opening **32** of the crucible **31** by the furnace lid supporting mechanism **54** to cover the opening **32**. By melting the melting material in this state, heat in the crucible **31** can hardly be dissipated to the outside. Accordingly, improvement in melting efficiency and working environment are achieved.

A point that the furnace lid **13** is used for the retention of the molten metal to improve efficiency of the melting operation is the same as the advantageous effect of the first embodiment.

The furnace lid **13** in the state of covering the opening **32** of the crucible **31** is provided below the hood **24**. By moving the furnace lid **13** from below the hood **24** to the waiting position, the opening **32** of the crucible **31** is positioned below the hood **24**, and thus the supply of the melting material to the crucible **31** is allowed. In other words, the melting material supply apparatus **50** do not have to be moved for supplying the melting material and for melting the supplied melting material, and thus the efficiency of the melting operation is improved correspondingly.

The furnace lid supporting mechanism **54** is provided below the melting material supply unit **12**, and is configured to, in this position, move the furnace lid **13** between the position at which it is placed at the opening **32** of the crucible **31** and the waiting position. Therefore, an area for moving the furnace lid **13** and an area used for the melting material supply unit **12** may be provided separately in a vertical direction. Accordingly, complication in structure due to interference of one configuration with the other configuration is restricted.

Looseness is provided at the coupled portion between the distal end **63** of the arm member **61** and the coupling member **14** on the furnace lid **13**, and in this state, the arm member **61** and the coupling member **14** are coupled. In addition, by the shaft portion **65** formed into a circular shape in cross section, the coupling member **14** and the furnace lid **13** are also allowed to incline. Therefore, with this looseness, even when the upper end of the crucible **31** is not in the horizontal state and is slightly inclined, the inclination is absorbed, and thus formation of a gap between the peripheral edge of the opening **32** and the furnace lid **13** is restricted.

Implementation of the present disclosure is not limited to the first and second embodiments described thus far, and the following implementation, for example, is also applicable.

(a) In the first embodiment described above, the furnace lid **13** is configured to be suspended and supported by the suspension lines **45**, **46** attached to the center portion of the lateral member **44**. Instead of this configuration, the suspension and support of the furnace lid **13** may be achieved by other configurations. For example, even in the case of suspending and supporting the furnace lid **13** by the same suspension lines **45**, **46**, a configuration in which a plurality of first suspension lines **45** are provided on the lateral member **44** to suspend and support the furnace lid **13** is also applicable. Furthermore, instead of a configuration using the pair of pivotable arm members **41** and the lateral member **44** as described in the first embodiment described above, a configuration in which the respective arm members **41** are fixed with the lateral member **44** disposed above the crucible **31** and a winding device for the first suspension line **45** provided on the lateral member **44** may be employed. In this case, the furnace lid **13** may be moved upward and downward by unwinding and winding the first suspension line **45** by the winding device.

In the same manner as the second embodiment, the lateral member **44** and the furnace lid **13** may be coupled by the coupling member **14** provided on the furnace lid **13**. In this case, by providing looseness at the coupled portion in the same manner as the second embodiment, even though the coupling member **14** cannot be sagged and shortened in length like the suspension lines **45**, **46**, the furnace lid **13** may be inclined by the looseness so as to follow the inclination of the opening **32** of the crucible **31**.

(b) In the second embodiment described above, the furnace lid **13** at the waiting position is configured to be accommodated in the furnace lid accommodating portion **51**. Instead of this configuration, a space between the base table portion **52** and the traveling path S may also be used, and hence the furnace lid **13** may be retained at a lower position. In this configuration, the height of installation of the melting material supply unit **12** may be lowered, and hence the distance between the material outlet port **25** of the hood **24** and the opening **32** of the crucible **31** may be reduced to restrict the melting material from splashing around.

(c) In the second embodiment described above, the furnace lid **13** employs the configuration in which the furnace lid **13** is coupled to the arm member **61** with the coupling member **14**. Instead of this configuration, the furnace lid **13**

may be suspended and supported by the distal end **63** of the arm member **61** by using the suspension lines **45**, **46** as in the first embodiment.

(d) In the second embodiment described above, the melting material supply apparatus **50** is movable along the movement direction by the wheels **11***a*. Instead of this configuration, the wheels **11***a* may be omitted, and the melting material supply apparatus **50** may be installed in a fixed state.

(d) In the respective embodiments described above, the configuration in which the hood **24** is provided on the melting material supply unit **12** is employed. Instead of this configuration, the hood **24** may be omitted.

(e) In the respective embodiments described above, the metal melting furnace employing the induction heating system using the induction coil **34** has been described. Instead of this configuration, a hybrid metal melting furnace in combination with heating by flames of a burner is also applicable. In this case, the furnace lid **13** is provided with a burner, and a gas supply tube for supplying fuel gas to the burner is also provided on the melting material supply apparatuses **10**, **50**.

REFERENCE SIGN LIST

10, **50** . . . melting material supply apparatus, **12** . . . melting material supply unit, **13** . . . furnace lid, **24** . . . hood, **25** . . . material outlet port, **31** . . . crucible, **32** . . . opening, **40** . . . furnace lid-supporter, **45** . . . suspension lines (inclination following mechanism), **55** . . . furnace lid supporting mechanism (furnace lid-supporting means, furnace lid moving means), **64** . . . elongated hole (inclination following mechanism), **65** . . . shaft portion (inclination following mechanism).

The invention claimed is:

1. A melting material supply apparatus combined with a metal melting furnace for melting a melting material supplied to a crucible of the metal melting furnace, the melting material supply apparatus comprising:

a melting material supply unit configured to supply a melting material to the crucible and to move between a supplying position for supplying the melting material to the crucible and a retracted position retracted therefrom and apart from the crucible which has been supplied with the melting material;

a furnace lid configured to cover an opening provided at a top of the crucible;

a furnace lid support mechanism configured to support the furnace lid in a horizontal state and to move the furnace lid between a first position at which the furnace lid is placed at the opening to cover the opening and a second position at which the opening is opened to allow a supply of the melting material,

wherein when the furnace lid is in the second position while the melting material supply unit moves from the supplying position to the retracted position, the furnace lid support mechanism moves with the melting material supply unit to move the furnace lid away from the crucible,

the melting material supply unit is provided on a base unit configured to move in a moving direction on a traveling path,

the base unit has a base table portion provided below the melting material supply unit and a furnace lid accommodating portion provided between the base table portion and the melting supply unit,

the furnace lid support mechanism has an arm member provided at the base table portion, said arm member supporting the furnace lid and configured to move in the furnace lid accommodating portion along the moving direction of the base unit, and

the furnace lid protrudes in front of the furnace lid accommodating portion in the first position, is accommodated in the furnace lid accommodating portion in the second position, and is configured to move between the first position and the second position by movement of the arm member.

2. The melting material supply apparatus according to claim **1**, wherein

the melting material supply unit has a hood disposed above the opening at the time of supplying the melting material into the crucible and having a material outlet port configured to lead out the melting material downward, and

the furnace lid at the first position is placed below the hood.

3. The melting material supply apparatus according to claim **1**, wherein the furnace lid support mechanism has an inclination following mechanism configured to cause the furnace lid to incline so as to follow an inclination of a contact portion with respect to the opening.

4. A melting material supply apparatus combined with a metal melting furnace for melting a melting material supplied to a crucible of the metal melting furnace, the melting material supply apparatus comprising:

a melting material supply unit configured to supply a melting material to the crucible and to move between a supplying position for supplying the melting material to the crucible and a retracted position retracted therefrom and apart from the crucible which has been supplied with the melting material;

a furnace lid configured to cover an opening provided at a top of the crucible;

a furnace lid supporter configured to support the furnace lid in a horizontal state and to move the furnace lid between a first position at which the furnace lid is placed at the opening to cover the opening and a second position at which the opening is opened to allow a supply of the melting material,

wherein when the furnace lid is in the second position while the melting material supply unit moves from the supplying position to the retracted position, the furnace lid supporter moves with the melting material supply unit to move the furnace lid away from the crucible,

the melting material supply unit is provided on a base unit moving in a one direction on a traveling path,

the furnace lid supporter has a pair of arm members provided at a front end of the base unit and supporting the furnace lid,

the pair of arm members are pivotable about a proximal end thereof as an axis of pivotal movement,

when the pair of arm members are pivoted to a downward position, the furnace lid is placed at the first position and when the pair of arm members are pivoted to a raised position, the furnace lid is placed at the second position.

5. The melting material supply apparatus according to claim **4**, wherein

the melting material supply unit has a hood disposed above the opening at the time of supplying the melting material into the crucible and having a material outlet port configured to lead out the melting material downward, and

the furnace lid at the first position is placed in front of the hood, and the furnace lid at the second position is placed above the hood, and

the pair of arm members moves the furnace lid so as to circumvent the hood when moving the furnace lid between the first position and the second position.

6. The melting material supply apparatus according to claim **4**, wherein the furnace lid supporter has an inclination following mechanism configured to cause the furnace lid to incline so as to follow an inclination of a contact portion with respect to the opening.

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